UNIVERSITI TEKNIKAL MALAYSIA MELAKA

Faculty of Electronic and Computer Engineering

ENHANCED IMAGE VIEW SYNTHESIS USING MULTISTAGE HYBRID MEDIAN FILTER FOR STEREO IMAGES

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ENHANCED IMAGE VIEW SYNTHESIS USING MULTISTAGE HYBRID MEDIAN FILTER FOR STEREO IMAGES

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A thesis submitted
in fulfillment of the requirements for the degree of Master of Science in Electronic Engineering

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DECLARATION

I declare that this thesis entitled "Enhanced Image View Synthesis Using Multistage Hybrid Median Filter for Stereo Images" is the result of my own research except as cited in the references. The thesis has not been accepted for any degree and is not concurrently submitted in candidature of any other degree.

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Date	:	....

APPROVAL

I hereby declare that I have read this thesis and in my opinion this thesis is sufficient in terms of scope and quality for the award of Master of Science in Electronic Engineering

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Supervisor Name	:	Assoc. Prof. Dr. Nurulfajar Bin Abd Manap
Date	:	…………………………………………...

DEDICATION

To my beloved mother and father

ABSTRACT

Disparity depth map estimation of stereo matching algorithm is one of the most active research topics in computer vision. In the field of image processing, many existing stereo matching algorithms to obtain disparity depth map are developed and designed with low accuracy. To improve the accuracy of disparity depth map is quite challenging and difficult especially with uncontrolled dynamic environment. The accuracy is affected by many unwanted aspects including random noises, horizontal streaks, low texture, depth map non-edge preserving, occlusion, and depth discontinuities. Thus, this research proposed a new robust method of hybrid stereo matching algorithm with significant accuracy of computation. The thesis will present in detail the development, design, and analysis of performance on Multistage Hybrid Median Filter (MHMF). There are two main parts involved in our developed method which combined in two main stages. Stage 1 consists of the Sum of Absolute Differences (SAD) from Basic Block Matching (BBM) algorithm and the part of Scanline Optimization (SO) from Dynamic Programming (DP) algorithm. While, Stage 2 is the main core of our MHMF as a post-processing step which included segmentation, merging, and hybrid median filtering. The significant feature of the post-processing step is on its ability to handle efficiently the unwanted aspects obtained from the raw disparity depth map on the step of optimization. In order to remove and overcome the challenges unwanted aspects, the proposed MHMF has three stages of filtering process along with the developed approaches in Stage 2 of MHMF algorithm. There are two categories of evaluation performed on the obtained disparity depth map: subjective evaluation and objective evaluation. The objective evaluation involves the evaluation on Middlebury Stereo Vision system and evaluation using traditional methods such as Mean Square Errors (MSE), Peak to Signal Noise Ratio (PSNR) and Structural Similarity Index Metric (SSIM). Based on the results of the standard benchmarking datasets from Middlebury, the proposed algorithm is able to reduce errors of *non-occluded* and *all* errors respectively. While, the subjective evaluation is done for datasets captured from MV BLUE FOX camera using human's eyes perception. Based on the results, the proposed MHMF is able to obtain accurate results, specifically 69% and 71% of *non-occluded* and *all* errors for disparity depth map, and it outperformed some of the existing methods in the literature such as BBM and DP algorithms.

ABSTRAK

Anggaran peta kedalaman perbezaan bagi algoritma penyesuaian stereo adalah salah satu topik penyelidikan yang aktif di dalam penglihatan komputer. Di dalam bidang pemprosesan imej, terdapat banyak algoritma penyesuaian stereo yang wujud untuk mendapatkan peta kedalaman perbezaan yang dibangunkan dan direka dengan ketepatan yang rendah. Untuk meningkatkan ketepatan peta kedalaman perbezaan adalah agak mencabar dan sukar apabila melibatkan persekitaran dinamik yang tidak boleh dikawal. Ketepatan ini dijejaskan oleh beberapa aspek yang tidak diingini seperti hingar rambang, jalur mengufuk, tekstur rendah, bukan tepian peta kedalaman, halangan dan ketidaksinambungan kedalaman. Oleh yang demikian, penyelidikan ini mencadangkan satu cara baru yang lebih berkesan melalui algoritma penyesuaian stereo secara hibrid dengan pengiraan ketepatan yang lebih signifikan. Tesis ini akan membentangkan secara terperinci berkenaan pembangunan, rekabentuk dan analisis prestasi bagi Penapis Median Hibrid Pelbagai Peringkat (MHMF). Terdapat dua bahagian utama yang terlibat di dalam teknik yang dibangunkan ini, iaitu dengan menggabungkan dua peringkat utama. Peringkat 1 mengandungi Jumlah Perbezaan Mutlak (SAD) daripada algoritma Penyesuaian Asas Blok (BBM) dan bahagian Pengoptimuman Analisa-garis (SO) daripada algoritma Pengaturcaraan Dinamik (DP). Sementara itu, Peringkat 2 adalah merupakan teras utama bagi langkah pasca pemprosesan MHMF, yang melibatkan pembahagian, penggabungan dan penapisan median hibrid. Ciri utama bagi langkah pasca pemprosesan ini adalah keupayaannya untuk menguruskan aspek yang tidak diingini dengan cekap dari peta kedalaman perbezaan yang mentah dari peringkat pengoptimuman. Untuk membuang dan menangani cabaran aspek yang tidak diingini, MHMF yang dicadangkan mempunyai tiga peringkat proses penapisan bersama dengan pendekatan yang dibangunkan di Peringkat 2 algoritma MHMF. Terdapat dua kategori penilaian yang diukur bagi peta kedalaman perbezaan yang diperolehi: penilaian secara subjektif dan penilaian secara objektif. Penilaian secara objektif melibatkan penilaian melalui sistem Penglihatan Stereo Middlebury dan penilaian secara teknik tradisional iaitu seperti Kesilapan Kuadrat Min (MSE), Nisbah Puncak ke Hingar Isyarat (PSNR) dan Indeks Metrik Kesamaan Berstruktur (SSIM). Berdasarkan keputusan yang diperolehi melalui set data penanda arasan piawai daripada Middlebury, algoritma yang dicadangkan berupaya untuk mengurangkan kesilapan pada tidak-terhalang dan kesemua kesilapan masing-masing. Sementara itu, penilaian secara subjektif telah dibuat untuk set data yang diambil melalui kamera MV BLUE FOX secara persepsi penglihatan manusia. Berdasarkan keputusan, MHMF yang dicadangkan berkeupayaan untuk mendapatkan keputusan yang jitu, iaitu 69% dan 71% secara spesifik untuk kesilapan tidak terhalang dan kesemua kesilapan bagi peta kedalaman perbezaan, dan mengatasi sebilangan teknik yang sedia ada di dalam kajian seperti algoritma BBM dan DP.

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LIST OF ABBREVIATIONS

1D	–	One Dimensional
2D	–	Two Dimensional
3D	–	Three Dimensional
AD	–	Absolute Difference
AR	–	Augmented Reality
AW	–	Adaptive Window
BBM	–	Basic Block Matching
BM	–	Bidirectional Matching
BF	–	Bilateral Filter
DP	–	Dynamic Programming
DSI	–	Disparity Space Image
GC	–	Graph Cut
GF	–	Guided Filter
GPU	–	Graphic Processing Unit
HMF	–	Hybrid Median Filter
IP	–	Internet Protocol
MF	–	Matching Function
MHMF	–	Multistage Hybrid Median Filter
MSE	–	Mean Squared Error
MW	–	Multiple Window
NCC	–	Normalized Cross Correlation
PSNR	–	Peak Signal to Noise Ratio

RMS	–	Root Mean Squared
RT	–	Rank Transform
SD	–	Squared Difference
SO	–	Scanline Optimization
SAD	–	Sum of Absolute Difference
SNR	–	Signal to Noise Ratio
SSD	–	Sum of Squared Differences
SSIM	–	Structural Similarity Index Metric
WTA	–	Winner Take All

LIST OF SYMBOLS

x	–	Pixel in column
y	–	Pixel in row
I	–	Image
d	–	Position increment of a pixel
W	–	Square window for aggregation
∇	–	Gradient
w	–	Absolute weighting
$*$	–	Multiply
P	–	Disparity plane
S	–	Segment
λ_{disc}	–	Common border lengths
C_{census}	–	Hamming distance between the correspondence pixels of left image and right image
d_p^*	–	Highest votes or bin value for the disparity
S_p	–	Total number of good pixels
d_p	–	Value of disparity map
E	–	Edges
m	–	Matching penalty
t	–	Threshold
N	–	Neighborhood
y_K	–	Data point upon the iteration

a_x	–	Number of pixels in the segment from data point of x
A	–	Aggregated area
Occ	–	Occluded pixels
σ_i	–	Input of noise variance
$f(\bar{n})$	–	Function of noise density
I_l	–	Image left
I_r	–	Image Right
w	–	Window support
Z	–	Depth

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